



## Voltammetric and spectrophotometric pathways for the determination of total antioxidant capacity in commercial turnip juice

Merve Ozturk<sup>a</sup>  , Ersin Demir<sup>b\*</sup>  , Tugba Ozdal<sup>\*b</sup>  

<sup>a</sup> Department of Food Engineering, Faculty of Engineering, Istanbul Okan University, Istanbul, 34959, Turkey

<sup>b</sup> Afyonkarahisar Health Sciences University, Faculty of Pharmacy, Department of Analytical Chemistry, 03030, Afyonkarahisar, Turkey

**Abstract:** In this study, total flavonoid substances, total phenolic substances, and total antioxidant capacity in turnip juice which made from the turnip (*Brassica rapa*), a plant belonging to the family of "Turpgiller" (*Brassicaceae*), and also a drink specific to the Çukurova, were investigated. The turnip juice samples, taken from the turnip juice (A sample) and hot turnip juice (B) sample in local market, prepared in the laboratory were performed as two different parallel assays. In addition, electrochemical method was used to evaluate total antioxidant capacity (TAC) of turnip juice and hot turnip juice. By the square wave stripping voltammetry (SWSV) method, under the optimized experimental conditions was applied for quercetin determination with a limit of detection (LOD) and limit of quantification (LOQ) of 0.017 and 0.057 µg/L, respectively. These values are satisfactory for application to real food samples for the evaluation of TAC. According to the results carried out by spectrophotometric methods, the highest total phenolic and flavonoid contents and TAC were observed as 13.049±0.40 g GAE/mL, 37.850±0.70 mg QE/mL and 81.831±3,24 mg TE/100 mL, respectively. In addition, the TAC in turnip juice and hot turnip juice were calculated as 573.05±0.43 mg/L and 854.98±9.9 mg/L by SWSV, respectively. The results obtained by voltammetric and spectrophotometric methods for determinations of TAC were in correlation and found to be compatible for the determination of TAC.

**Keywords:** Antioxidant; Turnip juice, Voltammetry, Spectrophotometry

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\* **Corresponding authors: Email:** [ersindemir@aku.edu.tr](mailto:ersindemir@aku.edu.tr); [tugba.ozdal@okan.edu.tr](mailto:tugba.ozdal@okan.edu.tr)

### INTRODUCTION

Antioxidants can be classified mainly in two groups, primary and chain-breaking. In addition, it can be divided into 5 groups as primary antioxidants, secondary antioxidants, enzymatic antioxidants, oxygen cleaners and chelating agents (1). Phenolic compounds directly contribute to the antioxidant capacity amount in foods (2). The most important effect of antioxidant compounds on human health inhibits the damage caused by free radicals in the body or prevents complete damage. The source of

free radicals (unpaired electrons) can be events such as prolonged exposure to X-rays, excessive smoking, intensely polluted air, and exposure to toxic industrial chemicals (3). It is recommended to consume food products with high antioxidant capacity against diseases such as cancer, cardiovascular disease, carcinogenesis, aging and Alzheimer's caused by free radicals (3, 4).

Turnip juice is produced from the turnip (*Brassica rapa*), a plant belonging to the family of *Brassicaceae*. Turnip juice consumption is very common in Turkey

although it is a drink specific to the Cukurova province. Although there are some differences in its production, purple carrots, radishes, bulgur flour, sour dough, salt, water and red powdered pepper are used in making turnip juice (5). Generally, two methods are dominant for the production of turnip juice. The first is the traditional method and the other is the direct method, which can vary locally (6). Turnip juice is a functional beverage with a very strong antioxidant activity due to its rich phenolic and anthocyanin content. Functional properties of turnip juice can be listed as cleaning the respiratory tract, regulating the digestive system, preventing cardiac and vascular diseases, and influencing the immune system in a positive direction (7). In turnip juice, the color comes from the black carrot, rich in phenolic content of the anthocyanins. During turnip juice fermentation lactic acid fermentation takes place that make a great influence on taste and odor characteristics of the product.

Turnip is one of the most effective antioxidant substances against cutaneous diseases thanks to its abundant vitamin C content. Turnip juice can also support the immune system by increasing blood cell function due to its rich content. Moreover, it inhibits free radicals caused blockages. It can also reduce the severity and duration of the common cold by reducing histamine levels. Thanks to glucosinolates, another important ingredient in turnip juice, it plays an important role in cancer treatment. Carrot, which is one of the raw materials of turnip juice, is an excellent source of antioxidants due to its abundant phenolic content, flavonoids and pro-vitamins. They detected abundant purple pigments and Cyanidine-3-glucoside derivatives, which can exhibit abundant purple pigments and chemopreventive and chemotherapeutic activity (8). Furthermore, purple carrots are known to contain more antioxidant, vitamin, carotenoid and phenolic compounds than colored carrot varieties such as orange, yellow and white (9). In conclusion, it is very important to investigate the amount of antioxidants of turnip juices, which is an important and natural drink for human health.

The various methods have been used to measure the *in vitro* antioxidant capacities of fruits and vegetables in the literature. Methods such as cupric ion reducing antioxidant capacity (CUPRAC) and 2,2-diphenyl-1-picrylhydrazyl (DPPH) are simple, cost-effective, easily interpreted and show either reduction capacity (CUPRAC) or direct free radical inhibition (DPPH) (10). While evaluating antioxidant capacity of a food or beverage, at least two of these assays should be combined to have a more reliable conclusion of the total antioxidant capacity (11). Furthermore, in routine antioxidant analyses, cheap, fast, sensitive, environmentally friendly, and reliable

new methods are needed. Electrochemical measurements draw great attention in this respect, especially since they are cheap, reliable, and environmentally friendly. Therefore, antioxidant studies with electrochemical methods have been concentrated in the last decade.

In this study, total antioxidant capacities (TAC) in commercial turnip juices were evaluated by voltammetric and spectrophotometric methods. In order to compare with the voltammetric and traditional analytical methods for the TAC, quercetin was chosen as a reference standard substance. Moreover, gallic acid, quercetin, and trolox were used to investigate for the total phenolic content analysis, total flavonoid analysis and total antioxidant capacities in spectrophotometric methods, respectively. In the electrochemical study, square wave stripping voltammetry (SWSV) was used under the optimum experimental conditions such as pH medium, accumulation time, frequency, and step potential, etc. were researched on carbon paste electrode (CPE). Thus, TAC values obtained by different methods were evaluated statistically. Consequently, TAC values of turnip juices were analyzed for the first time using both electrochemical and conventional analytical methods.

## EXPERIMENTAL

### Electrochemical Instrumentation

For the electrochemical measurements, Gamry Reference 600 Electrochemical Analyzer was used. The analyzer consists of triple electrode systems which is a platinum wire, a Ag/AgCl reference electrode and carbon paste electrode (CPE) (BASi MF 2010; Ø 3 mm, diameter) as working electrode. In addition, a voltammetric cell with 10 mL capacity was used for collecting the voltammetric data. The working electrode was performed using carbon nanotube powder (MER Corporation, mesh size < 53 µm) and mineral oil at a mass ratio of 70% and 30%, respectively. The carbon paste powder was plugged into the hollow part of the BASi MF 2010 electrode attached. After that, the electrode surface was polished on a polishing cloth. The pH measurements were performed by digital a pH meter (Mettler Toledo, S220).

### Reagents and solutions

The analytical standard of quercetin (≥98.0%) was purchased from Sigma-Aldrich. A 500 ppm stock solution of quercetin was prepared daily by dissolving it in water. All other reagents were provided analytical grade and used without further purification. 0.04 M Britton-Robinson (B-R) solutions were used as a supporting electrolyte by mixing of 2.7 mL of orthophosphoric, 2.5 g of boric, and 2.3 mL of acetic acids in distilled water. B-R buffer solutions were

prepared from pH 2.0 to 10.0 by adding the required amount of 5 M NaOH in this triple acid mixture and monitoring with a pH meter. All stock solutions were stored in a refrigerator at 4.0 °C. All electrochemical data were carried out at a comfortable ambient temperature  $25 \pm 2$  °C.

#### Food samples assay procedure

The commercial turnip juice samples were purchased from a local market. 0.1 mL of the real sample solution was directly placed into 10.0 mL of pH 7.0 B-R buffer solution without any purification and pretreatment food samples. Then, the SWSV measurements from - 0.2 to 1.3 V were obtained to determine the antioxidant capacity of food samples under optimum conditions (step potential ( $E_s$ ) 3 mV; frequency ( $f$ ) 300 Hz; pulse amplitude ( $E$ ) 110 mV; accumulation potential ( $E_{acc}$ ) 200 mV; accumulation time ( $t_{acc}$ ) 30 s and pH 7.0 B-R buffer solutions). For all the food samples, the measurements were performed in triplicate and the validation parameters were calculated.

#### Spectrophotometric Methods

Two types of turnip juice (hot turnip juice and basic turnip juice) were purchased from local market. According to the results of 1,1-diphenyl-2-picrylhydrazyl (DPPH) and cupric reducing antioxidant capacity (CUPRAC) methods, total phenolics, total flavonoids, and antioxidant capacities in turnip juice samples were determined.

#### Sample preparation

Two different turnip juice samples (hot and basic) were diluted 1/10 and 1/100 using 80% methanol and samples were subjected to vortex mixer for 30 seconds in sterile sample containers and then stored in a refrigerator at -18 °C. Examples in the research were carried out by spectrophotometry in the food engineering laboratory of Okan University.

#### Determination of total phenolic content

Total phenolics determination was performed colorimetrically as developed slightly by Shahidi and Naczka (12). For this, Folin-Ciocalteu's phenol reagent and gallic acid solutions were prepared with 7.5%  $\text{Na}_2\text{CO}_3$  in milli-Q water and distilled water, respectively. The phenol reagent of Folin-Ciocalteu was kept in the dark when not in use. 50  $\mu\text{L}$  of diluted phenolic extract, in 1.5 mL of 7.5% sodium carbonate solution and 1.5 mL of Folin-Ciocalteu's Phenol Reagent was homogeneously mixed with vortex in test tubes. A standard calibration graph was created for gallic acid at a concentration of 0.01 to 0.8 g/L in 80% methanolic solution. Absorbance measurements were obtained at 765 nm using the Beckman Coulter DU 730 Life Science UV/Vis Spectrophotometer. The measured blank solution's absorbance was removed from the absorbance of the sample and standard

substances. The measurements taken for each turnip juice sample were repeated three times. As a result, the content of phenolics was calculated as mg gallic acid equivalent (GAE)/100 g of dry weight.

#### Determination of total flavonoid content

Total flavonoids in turnip juice were measured colorimetrically as described by Dewanto et al. (2002), Zhishen et al. (1999) and Lee et al. (2003) (13-15). Firstly, stock solutions such as 5% sodium nitrite ( $\text{NaNO}_2$ ), 1 M sodium hydroxide (NaOH), 10% aluminum chloride hexahydrate ( $\text{AlCl}_3 \cdot 6\text{H}_2\text{O}$ ) and quercetin (1 g/L) were prepared very precisely. 1 mL of diluted turnip sample was mixed with 0.3 mL of 5%  $\text{NaNO}_2$ . Then 0.6 mL of 10%  $\text{AlCl}_3 \cdot 6\text{H}_2\text{O}$  and 2 mL of 1 M NaOH were added. Finally, 2.4 mL of water was added quickly and vortexed immediately. Calibration graphic for quercetin was created in different concentrations between 0.01 g/L and 0.8 g/L in 80% methanolic solution. Absorbance data were obtained in 80% methanol solution at 510 nm using Shimadzu UV-1700 Pharmospec UV-Visible Spectrophotometer and all analyses were also performed in triplicate. The content of flavonoids in turnip juices was calculated as mg quercetin/100 mL sample.

#### Determination of antioxidant capacity according to DPPH method

For the amount of antioxidant in turnip juices, colorimetric method was used as described by Kumaran (2006) and Rai et al. (2006) (16, 17). 1 mM DPPH solution was prepared from methanol. The absorbances of turnip juice samples were collected against the methanol blank solution at 517 nm using Shimadzu UV-1700 Pharmospec UV-Visible Spectrophotometer. The calibration plot for Trolox was obtained between 0.01 g/L and 0.8 g/L in 80% methanol solution. All analyses were performed three times for each turnip sample, and the results were calculated in mg Trolox equivalent (TEAC).

#### Determination of antioxidant capacity according to CUPRAC method

Antioxidant capacities of turnip juice samples were analyzed colorimetrically by CUPRAC method developed by Apak et al. (2004) (18). In the first stage of the study, solutions of copper (II) chloride at a concentration of 0.01 M, neocuproine (Nc) in ethanol at a concentration of  $7.5 \times 10^{-3}$  M, and ammonium acetate ( $\text{NH}_4\text{Ac}$ ) buffer at pH 7.0 was prepared very precisely. Moreover, the solutions used in the whole experiment were prepared daily. 1 mL of copper (II) chloride solution, 1 mL of ammonium acetate buffer and 1 mL of neocuproine were added to 100  $\mu\text{L}$  of the turnip samples. Absorbance data were obtained in 80% methanol solution at 450 nm using Shimadzu UV-1700 Pharmospec UV-Visible Spectrophotometer and all analyses were performed in triplicate. Calibration graph for Trolox was created in different

concentrations between 0.01 and 0.8 g/L in 80% methanol solution. All analyses were performed in triplicate for each turnip sample, and the results were calculated in mg trolox equivalent (TEAC).

### Statistical Analysis

Student's t-test was performed to understand if there are statistically significant ( $p < 0.05$ ) differences between total flavonoid contents and total phenolics, total antioxidant capacities of two turnip juice samples in spectrophotometric method. Electrochemical analysis results for total antioxidant capacities in turnip juice samples were obtained on the standard calibration chart. Results were calculated as mean and standard deviation.

## RESULTS AND DISCUSSION

### Electrochemical Analysis

In analytical chemistry, electrochemical methods are used for investigating a huge scale of substances. For example, metal ions and organic compounds are discovered in pesticides, food, and medicine. They are generally quick and cheap. The using of electrochemical methods, investigations of antioxidant in food sources have been analyzed by some groups (19-23). Cyclic voltammetry (CV) and differential pulse voltammetry (DPV) and square wave voltammetry (SWV) have been mostly used for electrochemical species, because the results give very fast and reliable results in total antioxidant capacity (TAC) analysis (24-26). It is imaginable to have quantitative analysis of antioxidant present in the samples. The different groups of antioxidants compound such as phenolics and ascorbic acid show

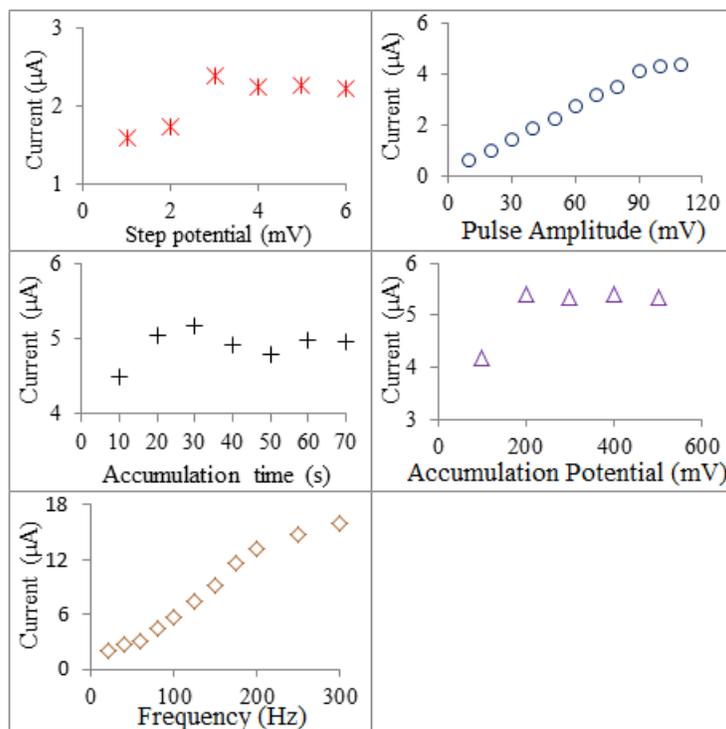
different oxidation potential which shows the results in different regions of antioxidants, a mignon number of electrochemical methods can be discovered in the literature.

### Optimization of the Parameters

The influence of step potential ( $E_s$ ) was studied by step potentials from 1 mV to 6 mV. The peak current increased at between 1 mV and 3 mV and then it shows stability after 3 mV for step potentials. Hence, 3 mV was chosen as the optimum step potential for the subsequent experiments. The effect of pulse amplitude ( $E$ ) was also determined various amplitudes from 10 mV to 110 mV. The oxidation peak signal increased until 90 mV linearly. That is why 110 mV was chosen as the optimum pulse amplitude because the maximum result is obtained from 110 mV. In addition to these steps, accumulation time ( $t_{acc}$ ) was determined from 10 s to 70 s. Until 30 s, the oxidation peak current was increased. After this point, accumulation time was not depended on peak current of quercetin because electrode surface is saturated fully. Therefore, optimum accumulation time was chosen as 30 s. The next step is accumulation potential ( $E_{acc}$ ) was studied from 100 mV to 600 mV. The increase of peak current started at 100 mV and after 200 mV, it showed stability until 600 mV. The available accumulation potential is 200 mV. The impact of frequency ( $f$ ) was evaluated between 20 Hz and 300 Hz. The peak current gradually increased between 20 and 300 Hz. Therefore, the optimum frequency was used as a 300 Hz at subsequent measurements. The optimized parameters for the SWSV in 1 mg/L quercetin were shown in **Figure 1** and **Table 1**.

**Table 1.** Optimized parameters of SWSV for the determination of quercetin.

Parameters	Optimized values/unit
Step potential ( $E_s$ )	3 mV
Pulse amplitude ( $E$ )	110 mV
Accumulation potential ( $E_{acc}$ )	200 mV
Accumulation time ( $t_{acc}$ )	30 s
Frequency ( $f$ )	300 Hz
Supporting electrolyte	pH 7.0 B-R Buffer solution
Peak Potential	+200 mV



**Figure 1.** Optimized parameters for the SWSV in 1 mg/L quercetin.

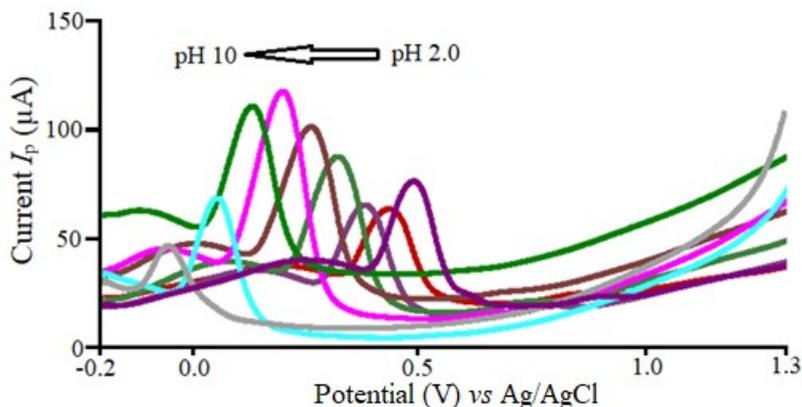
### Influence of pH

In the electrochemical studies, supporting electrolyte is one of most important parameters due to the effects on peak potential, current intensity can also affect the electrode kinetics in the charge transfer process. Hence, the effects of the supporting electrolyte anodic signal of quercetin at various pH values on the carbon paste electrode (CPE) were investigated. In order to determine the pH effect, square wave stripping (SWS) voltammograms were taken in the Britton-Robinson buffer solutions between pH 2.0 and pH 10.0 for the 1 mg/L quercetin. SWS experiments that the highest signals were obtained in moderate medium at pH 7.0 were found to be dependent on the below  $\text{pH} \leq 10.00$  buffer solutions. In addition, the oxidation peak potential of quercetin

gradually increased linearly between potential from pH 3 to pH 7 per unit pH changes. Significant decreasing in the quercetin peak current of quercetin was observed pH 7.0 then to up pH 10.0. Also, peak potential of the quercetin was a change as 65.28 mV by increasing as unit pH. This is the evidence that consumption of hydrogen ions contains in the electrochemical oxidation process. Britton-Robinson buffer solution at pH 7.0, where maximum peak flow was obtained for the determination of quercetin on the CPE, was determined as the ideal support electrolyte. Figure 2 shows the influence of pH for the peak I. (1 mg/L of quercetin from pH 2.0 to pH 10.0)

$$E_p \text{ (mV)} = - 65.28 \text{ pH} + 635.97 \text{ (mV)} \text{ (} R^2 = 0.9919 \text{)}$$

$$E_p \text{ (mV)} = - 50.85 \text{ pH} + 990.6 \text{ (mV)} \text{ (} R^2 = 0.9996 \text{)}$$



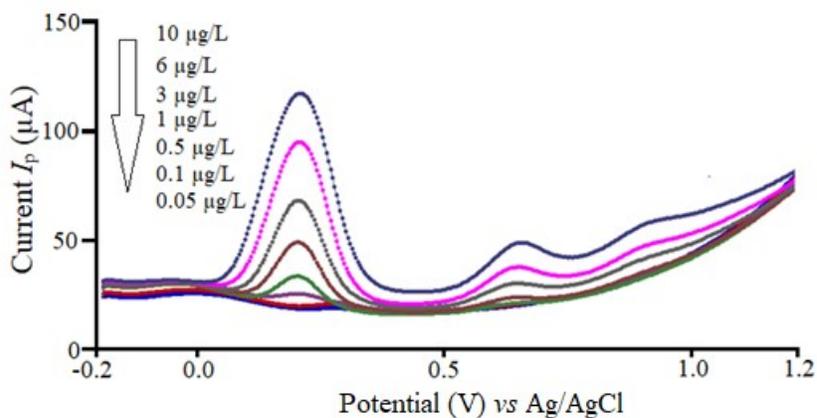
**Figure 2.** The pH effects on the peak I in 1 mg/L of quercetin by SWSV.

### Quantitative evaluation and validation of Quercetin

Peak current values against concentration were evaluated for anodic peak I of quercetin by using CPE. The peak intensities changed in a way to increase linearly as a result of increasing quercetin concentrations by SWSV on CPE in pH 7.0 (**Figure 3**). As a result of this change, a linear working range between 0.04 µg/L and 10 µg/L was obtained on the calibration graph. The limit of determination (LOD) and limit of detection (LOQ) were calculated as 0.017

µg/L and 0.057 µg/L, respectively. In calculating LOD and LOQ values,  $LOD = 3 s/m$  and  $LOQ = 10 s/m$  equations were preferred. The “m” is the slope of the calibration equation of the quercetin and the “s” is the standard deviation of the point where the concentration in the calibration equation is zero. Validation parameters of the calibration chart for quercetin determination are summarized in Table 2.

$$I_p (\mu A) = 0.203 (C, \mu g/L) - 0.032 \quad r = 0.9934$$



**Figure 3.** SWS voltammograms for the calibration graph of quercetin on CPE in pH 7.0.

**Table 2.** Validation parameters for determination of quercetin by SWS on CPE.

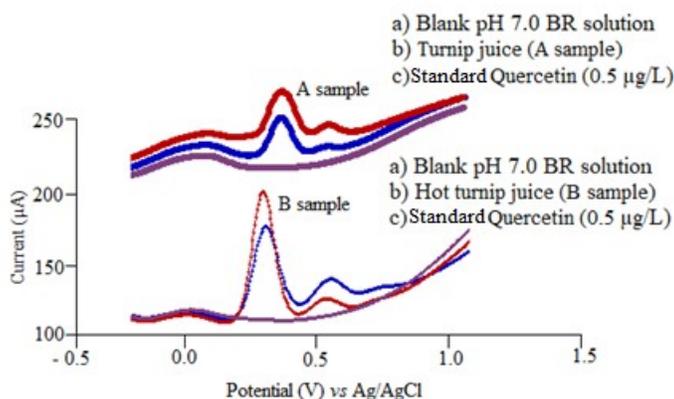
Parameter	Value
Peak potential ( $E_p$ ) (mV)	+ 200
Working range (µg/L)	0.04 – 10.0
Slope (µA L/µg)	0.203
Intercept (µA)	- 0.032
Limit of determination (LOD) (µg/L)	0.017
Limit of detection (LOQ) (µg/L)	0.057
Correlation coefficient	0.9934

### The determination TAC in turnip juices on CPE by SWSV

With the increasing importance of antioxidant substances in recent years, scientists are researching new analytical methods for antioxidant capacity determinations. A standard method for the determination of antioxidants, especially in complex samples such as food, has not yet been fully developed. Analytical methods such as chromatography, spectrophotometry, capillary electrophoresis, and spectrofluorometric analyses have been widely preferred in determining antioxidant capacity. However, the working principles of these methods are very different from each other. The common problems of these methods are them being expensive, analysis times are long and they are using too many chemicals. In addition, using less organic solvent is an important indicator for environmentally friendly methods. For these reasons, electrochemical methods, which are a fast, cheap, and reliable method that require less solution, are of great interest in antioxidant determinations. Furthermore, electrochemical methods are included not only in the determination of antioxidants, but also in the analysis

of many different substances such as drugs, pesticides, metals, vitamins and amino acids.

In this study, the total antioxidant capacity of turnip juices purchased from the local market was examined for the first time with a CPE using quercetin as the reference compound. Firstly, turnip juice samples were diluted 10 times with methanol and analyzed directly by SWSV method in buffer solutions at pH 7.0. SWS voltammograms were obtained in turnip samples under the optimization conditions for standard quercetin solutions. Then, by adding standard quercetin as a 0.5  $\mu\text{g/L}$  in the turnip juice samples, the total antioxidant capacity was calculated as equivalent quercetin from the peak current increase. Figures 4a and 4b represent the electrochemical analysis on carbon paste electrode for the total antioxidant capacity of turnip juice as sample A and sample B by SWSV, respectively determination of the total antioxidant capacity in turnip juices with SWSV is given in Table 3. Consequently, TAC values found by electrochemical method are mostly compatible with the results of total flavonoid contents.



**Figure 5.** Electrochemical determination pathway of total antioxidant capacity for the turnip juice samples by SWSV on carbon paste electrode.

**Table 3.** The determination of the total antioxidants capacity (TAC) for the turnip juices by SWSV on carbon paste electrode.

Sample	Total antioxidant capacity Equivalent Quercetin	RDS,%
A	573 $\pm$ 0.43 mg/L	0.07
B	854 $\pm$ 9.90 mg/L	1.16

### Spectrophotometric Analysis Total Phenolic and Flavonoid Contents

The concentrations of phenolic compounds in a sample can vary. In addition, phenolic compounds are very rare to be found in the samples in free form. It is generally more likely to exist in the form of glycosides or ester forms with carboxylic acid. Moreover, there is a possibility that phenolic compounds bind to fatty

acids, sterols and cellular walls. The amount of total phenolic of sample A and sample B were found as 11.361 $\pm$ 0.49 mg GAE/mL and 13.049 $\pm$ 0.40 mg GAE/mL, respectively (**Table 4**). According to the results of the total phenolic content, it was determined that the total phenolic content in the B sample as hot turnip juice was higher than the A sample as turnip juice. Moreover, the total flavonoid

content of sample B ( $37.850 \pm 0.70$  mg QE/mL turnip juice) was also found to be higher than sample A ( $23.894 \pm 0.55$  mg QE/mL turnip juice) about 58.41% as shown in Table 4. Furthermore, the total flavonoid content in turnip samples was very close to the

electrochemical results in percent. Compared to sample A with electrochemical methods, there was 49.04 percent increase in sample B, while this ratio was 58.41 percent with total flavonoid content.

**Table 4.** The total phenolic and flavonoid contents of turnip juice samples.

Sample	Total Phenolic Contents (mg GAE/mL turnip juice)	Total Flavonoid Contents (mg QE/mL turnip juice)
A (Turnip Juice)	$11.361 \pm 0.49^a$	$23.894 \pm 0.55^a$
B (Hot Turnip Juice)	$13.049 \pm 0.40^a$	$37.850 \pm 0.70^a$

In the study of Ekinci et al. (2016), the total phenolic content of turnip juice was found as  $0.000517 \pm 0.072$  mg GAE/mL (27). Our results for total phenolic content were higher than their result. However, Öztan (2006) was found the total phenolic content of turnip juice as 15.5 mg GA/mL which is in accordance with our results (28).

#### Antioxidant capacity according to DPPH and CUPRAC Analyses

The antioxidant activity of turnip juice samples were investigated as TE (mg TE/g mL) by DPPH and CUPRAC

methods. The antioxidant activity in sample B was higher than those of sample A using both methods. Antioxidant activities in turnip juice and hot turnip juice were found as  $57.634 \pm 3.01$  mg TE /100 mL and  $81.831 \pm 3.24$  mg TE /100 mL, respectively by the DPPH assay (Table 5). On the other hand, antioxidant activity of turnip juice samples were found as  $561.18 \pm 45.72$  mg TE / 100 mL for sample A and  $619.94 \pm 186.58$  mg TE /100 mL for sample B by CUPRAC analysis (Table 5).

**Table 5.** Antioxidant capacities of turnip juice samples according to DPPH and CUPRAC analyses.

Sample	DPPH (mg TE/100 mL turnip juice)	CUPRAC (mg TE/100 mL turnip juice)
A (Turnip Juice)	$57.634 \pm 3.01^b$	$561.18 \pm 45.72^a$
B (Hot Turnip Juice)	$81.831 \pm 3.24^a$	$619.94 \pm 186.58^a$

#### Statistical Analysis

According to *t*-test, *t* values were found to be 0.438 and 1.238 for total phenolic and total flavonoid analyses, respectively. Therefore, there were no statistically significant difference between two turnip juice samples according to their total phenolic and flavanoid contents. However, there were statistically significant differences between amounts of antioxidant of two samples according to DPPH analysis ( $p < 0.05$ ) as *t* value was found to be 0.0003. There were no statistically significant differences ( $t$ -value=0.312;  $p > 0.05$ ) between two samples according to their antioxidant capacities measured by CUPRAC analysis.

#### CONCLUSION

Herein, flavonoid contents, phenolic contents, and total antioxidant capacities in turnip juices were investigated. Since the above methods are different from each other in terms of analysis principles and reaction conditions, a single method is not sufficient to show all antioxidant properties. For this reason, this study compared the four most commonly used spectrophotometric tests. The highest phenolic and flavonoid components and antioxidant activities were obtained from hot turnip juice (B sample). This study was carried out by electrochemical analysis except for

spectrophotometric tests. A sensitive SWSV method was applied using the carbon paste electrode for the direct development of total antioxidant capacity (TAC) in turnip juices. Using the SWSV method developed for standard quercetin as antioxidant agent determine the total antioxidant amounts in turnip samples were carried out with the standard addition method. To ensure the accuracy and feasibility of the method, the optimized SWS voltammetric procedure was used directly, without any pre-treatment to samples. Consequently, the data obtained by new SWSV electrochemical method which is fast, easy, portable for the determination of antioxidants is compatible with the results of the total flavonoid content most among other spectrophotometric methods. According to all analytical methods, it has been proved that the antioxidant capacity of hot turnip juice is higher than that of normal turnip juice.

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